Cocunut shell and Waste Glass based Concrete - A comparative Study

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Abstract* - Concrete is the premier civil engineering material. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water & admixtures. Among all the ingredients, aggregates form the major part. More than 50000 billion tonnes of aggregate are produced each year in the world. Use of natural aggregates in such a rate leads to a question about the preservation of natural aggregate sources. In addition, operation associated with aggregates extraction and processing is the principal causes for environmental concern. The most widely used fine aggregate for the making of concrete is the natural sand mined from the riverbeds. However, the availability of river sand for the preparation of concrete is becoming scarce due to the excessive non-scientific methods of mining from the riverbeds, lowering of water table, sinking of the bridge piers, etc. are becoming common. The present scenario demands identification of substitute materials for the river sand for making concrete. Recently in the environmental issues, restrictions of local and natural access or sources and disposal of waste material are gaining great importance. Today, it becomes more difficult to find a natural resource. Use of the waste materials not only helps in getting them utilized in cement, concrete and other construction materials, but also has numerous indirect benefits such as reduction in land fill cost, saving in energy, and protecting environment from possible pollution effect. It also helps in reducing the cost of concrete manufacturing. In light of this in the contemporary civil engineering construction, using alternative materials in place of natural aggregate in concrete production makes concrete as sustainable and environmentally friendly construction material. In this research, the effect of coconut shell as partial replacement of coarse aggregate and waste glass as partial replacement of fine aggregate on the properties of concrete were studied. The characteristic properties of concrete such as compressive strength, flexural strength, and water absorption of various mixes were reviewed in this work.

1. INTRODUCTION

In a developing country like India a huge amount of industrial waste and agricultural waste is polluting the environmental. With a view to the above, this study aims at utilization of waste materials like coconut shell and waste glass in concrete construction industry for value added application i.e. waste management. Use of such waste materials not only helps in getting them utilized in cement, concrete and other construction materials, but also has numerous indirect benefits such as reduction in land fill cost, saving in energy, and protecting environment from possible pollution effect. It also helps in reducing the cost of concrete manufacturing. With increasing concern over the excessive exploitation of natural aggregates, synthetic lightweight aggregate produced from environmental waste is a viable new source of structural aggregate material. In addition use of such wastes can improve the properties of construction materials as well. Moreover, the production of cement and other concrete raw materials has increased dramatically over the past 80 years due to a continuous increase in demand for concrete. In view of this, the significance of this study is to show that the replacement of aggregates in concrete by coconut shells and waste glass leads to economy in the concrete utilization sector. The use of such waste materials in concrete can be an important step towards sustainability of the construction industry by ensuring a scenario having less environmental impacts. Further we know pozzolanic materials like glass are materials of current use in concrete. Their main purpose is usually the mitigation of Alkali Silica Reaction (ASR), especially deleterious in concrete structures, which is achieved by the development of a faster pozzolanic reaction, conferring additional strength to mortars and concretes. Similarly Coconut shell being a hard and not easily degrade material if crushed to smaller size can be a potential material to partially substitute coarse aggregates in concrete. The concrete with ground coconut shell was found to be durable in terms of its resistance in water, acidic and alkaline surrounding.

2. LITERATURE REVIEW

Many research's have been carried out on the utilization of waste products in concrete as a replacement of natural sand and gravel. Such waste products include discarded tires, plastic, glass, burnt foundry sand, coconut shells, coal combustion by-products etc. Each of these waste products has provided a specific effect on the properties of fresh and hardened concrete. The use of waste products in concrete not only makes it economical, but also helps in reducing disposal problems. Many efforts have been made to present a detailed review about various waste and recycled materials that can be effectively used in concrete as aggregate replacements. Various waste management options and researchs have been framed out and published by various researchers on the effect of waste materials including waste glass and coconut shells on the fresh and hardened properties of concrete.

1. They have studied about seek to greener environment since it seeks to develop recycle waste material for construction. The use of recycle aggregates and solid wastes from construction and demolition waste is showing a prospective application in construction and as alternative to primary and natural aggregate. It conserves natural resources and reduces the space required for land fill disposal. In the laboratory the crushed waste glass and ceramic tires have been tried as partial replacement substitute to convectional aggregate in concrete. They tested concrete for compressive strength, split tensile and flexural strength after a curing

period of 7, 28, 56 days. The results indicate effectiveness of crushed glass waste and ceramic waste as partial replacement of conventional aggregate up to 40 percent, without affecting the design strength.

(SOURCE: R. Kamala and B. Krishna Rao)

2. They have studied on the issues of environmental and economic concern had addressed by the use of waste glass as partial replacement of fine aggregates in concrete. Fine aggregates had replaced by waste glass powder as 10%, 20%, 30% and 40% by weight for M-25 mix. The concrete specimens had tested for compressive strength, splitting tensile strength, durability (water absorption) and density at 28 days of age and the results obtained had compared with those of normal concrete. They have resulted permissibility of using waste glass powder as partial replacement of fine aggregates up to 30 percent by weight for particle size of range 0-1.18mm.

(SOURCE: Mohd Iqbal malik and ors)

3. They have studied the strength of coconut shells(CS) replacement and different and study the transport properties of concrete with CS as coarse aggregate replacement. They concluded that. a. Increase in CS percentage decreased densities of the concrete. b. With CS percentage increased the 7 days strength gain also increased with corresponding 28 days curing strength.

(SOURCE: Amarnath Yerrmalla (2012))

4. They have studied that Aggregates provide volume at low cost, comprising 66 percent to 78 percent of the concrete. Conventional coarse aggregate namely gravel and fine aggregate is sand in concrete will be used as control While natural material is coconut shell as course aggregate will be investigate to replace the aggregate in concrete.

(Source: Kulkarni V.P, Kumar S)

5. They have studied that to enhance green construction environment we can use lightweight concrete. The possibility exists for the partial replacement of coarse aggregate with coconut shell to produce lightweight concrete. Coconut shell exhibits more resistance against crushing, impact and abrasion, compared to crushed granite aggregate. Coconut shell can be grouped under lightweight aggregate.

(SOURCE: Akshay Shelke, Pooja Kunjekar and Shraddha Gaikwad of Prof. Ram Meghe College of Engineering and Management, Amravati, Maharashtra, India)

3. OBJECTIVES OF THE RESEARCH

The main objective of the study is to use the waste materials (coconut shells and glass waste) in place of coarse and fine aggregates respectively for the positive variations in the properties of the concrete and also its impact on the economic growth of the construction industry and to explore the use of replaced materials. Further, the effects of materials used as aggregates are to be determined by testing workability, tensile strength, compressive strength, durability, etc. of cement concrete. These tests will enable a complete characterization and an evaluation of application possibilities. The main objectives of the study are summarized below;

1. To investigate the influence of partial replacement of coarse aggregates& fine aggregates by coconut shells and waste glass respectively on mechanical properties of concrete. Study on effect of change in percentage of coconut shells and waste glass (separately and in combination) on properties of concrete will also be deemed as an important part of present experimental investigation.
2. To find economical solution for high cost aggregate material like sand and gravel and hence making concrete construction more sustainable.
3. To prepare lightweight concrete by using coconut shell as course aggregate and waste glass as fine aggregate.
4. Utilization of waste glass in the concrete construction sector, hence eliminating the need of land fill disposal of this non biodegradable waste.

4. METHODOLOGY

The first step in the project was to collect the raw materials to be used as aggregate replacements. After that the casting was started. Two samples were made for each formulation (each mix proportion) followed by the testing of samples at 7days and 28 days.

Collection of raw materials.

The constituent materials used in this investigation were procured from local sources. Ordinary Portland cement of C53 grade was used. The cement and sand are easily available in the market. Well graded river sand passing through 1.18mm and retained on 75 micron sieve was used as fine aggregate. Coconut shells which were already broken into two pieces were collected from local a local coconut dealer, air dried for five days approximately at the temperature of 20 - 25 degree Celsius and then fibre and husk was removed from dried shells. Further the shells were broken into small chips manually using hammer and sieved through sieve analyzer. The material passing through 20mm sieve and retained on 12mm was used to replace coarse aggregate with Coconut Shell.

Fig 1: Coconut shells.

For this Project waste glass was obtained from the ongoing construction of buildings in the university campus itself. Glass waste obtained was first broken down completely in the los Angles. Abrasion testing machine and then the sieve analysis was done to obtain the waste glass passing through 1.18 mm and retained on 75 micron sieve

Fig 2: Los angles abrasion machine

Fig 3: Glass waste crushed through abrasion machine

Preparation of Samples.

All samples were prepared in the Concrete technology laboratory at IUST campus during the months of March -June, 2015. The samples for compression testing were cubes of size (15cm x15cm x15cm) while the beams of size (50cm x 10cm x 10cm) were used for flexure testing. The various steps involved in the sample preparation process are given below.

Mixing.

M20 mix with 1 : 1.5 : 3 ratio of cement, fine aggregate and coarse aggregate respectively was prepared for each sample. For replaced samples, different percentages of fine and coarse aggregates were replaced by waste glass and the coconut shell respectively. The water/cement ratio was kept as 0.45 for all mixes. The proportioned mix was blended together by hand, and then water was added to it in small quantities. The concrete was mixed continuously by hand using trowels till the appropriate mortar consistency is reached. The mix proportions for various concrete samples are tabulated as following:

Table no. 1 : **Mix proportion for various mixes.**

S. No.	Mix ID	Cement (kg/m^3)	Coarse Aggregates		Fine Aggregates		W/C Ratio
			Gravel (kg/m^3)	Coconut shells (kg/m^3)	River sand (kg/m^3)	Waste glass (kg/m^3)	
01.	P.C	440	1320	0	660	0	0.45
02.	C_{10}	440	1188	132	660	0	0.45
03.	C_{20}	440	1056	264	660	0	0.45
04.	C_{30}	440	924	396	660	0	0.45
05.	F_{10}	440	1320	0	594	66	0.45
06.	F_{20}	440	1320	0	528	132	0.45
07.	F_{30}	440	1320	0	462	198	0.45
08.	$C_{10}F_{10}$	440	1188	132	594	66	0.45

09.	$C_{10}F_{20}$	440	1188	132	528	132	0.45
10.	$C_{10}F_{30}$	440	1188	132	462	198	0.45
11.	$C_{20}F_{10}$	440	1056	264	594	66	0.45
12.	$C_{20}F_{20}$	440	1056	264	528	132	0.45
13.	$C_{20}F_{30}$	440	1056	264	462	198	0.45
14.	$C_{30}F_{10}$	440	924	396	594	66	0.45
15.	$C_{30}F_{20}$	440	924	396	528	132	0.45
16.	$C_{30}F_{30}$	440	924	396	462	198	0.45

Where C represents coconut shells as coarse aggregates and F represents waste glass as fine aggregate and the subscripts 10, 20, 30 represent their percentage replacements in concrete.

5. RESULTS AND INTERPRETATIONS.

The results show the variation in Compressive strengths and Flexural strengths of various concrete mixes in which the fine and coarse aggregates were replaced by various percentages of glass waste and coconut shells respectively. The results of various tests on materials used in the project are also mentioned in this chapter.

5.1 Standard Consistency for cement.

Table no. 2 : **Consistency results.**

Sample	Consistency(%)	Mean
SC	0.32	0.28
	0.26	
	0.28	
FG-10	0.31	0.27
	0.26	
	0.25	
FG-20	0.26	0.28
	0.28	
	0.30	

Where;
SC represents standard cement.
FG-10 represents 10% replacement by waste glass.
FG-20 represents 20% replacement by waste glass.

Initial & Final setting times

Table no. 3 : **Initial and final setting time.**

Sample	Initial setting time(hrs).	Final setting time(hrs).	Mean initial setting time(hrs).	Mean final setting time(hrs).
SC	0.6	5.63	0.54	5.51
	0.55	5.41		
	0.49	5.5		
FG-10	0.5	5.01	0.45	5.05
	0.43	5.08		
	0.44	5.07		
FG-20	0.44	5.29	0.41	5.23
	0.4	5.18		
	0.39	5.24		

Abrasion and Crushing for Coarse Aggregates

Table no.4 : **Crushing and Abrasion Values**

	Natural Aggregates.	Coconut Shells.	Mean of natural agg.	Mean of coconut shells.
Abrasion value (%).	2.1	1.7	1.89	1.78
	1.9	2.1		
	1.67	1.54		
Crushing value (%).	7.2	2.6	6.53	2.73
	6.5	2.9		
	5.9	2.7		

5.4 Water Absorption for Coarse and Fine Aggregates.

Table no. 5 : **water absorption results.**

Sample	Water Absorption value (%).	Mean absorption value(%).

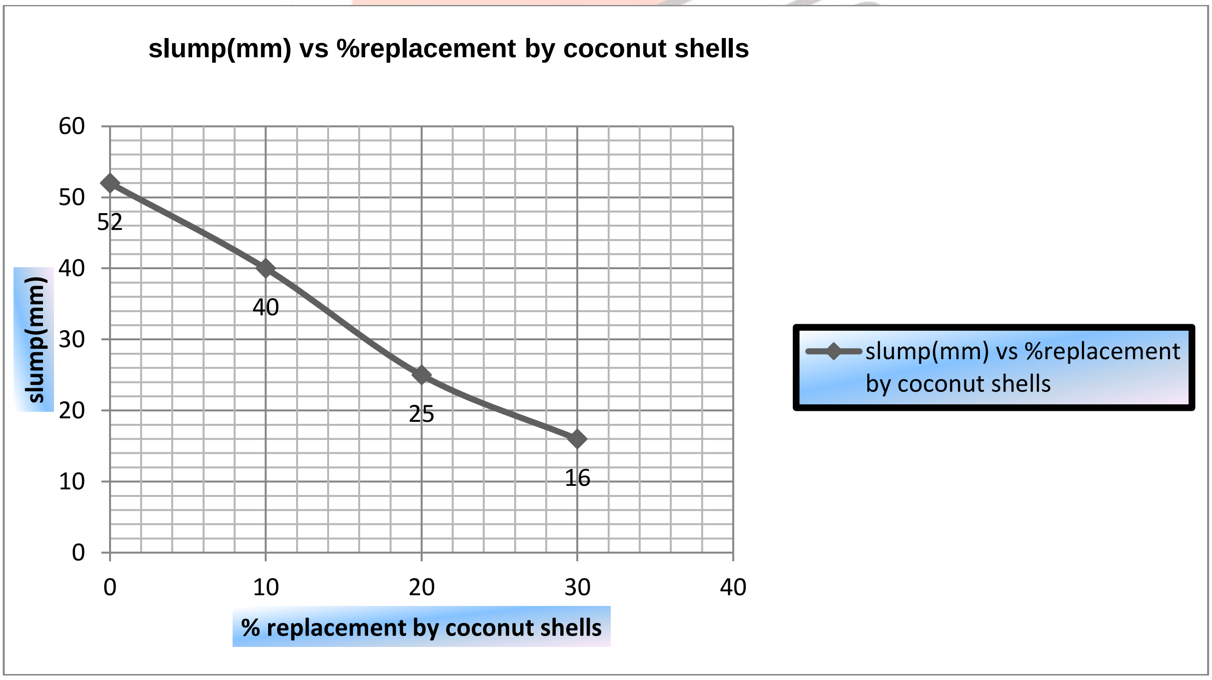
Coarse Aggregates.	Gravel.	0.72	0.68
		0.65	
		0.68	
	Coconut Shells.	33	28.3
		25	
		27	
Fine Aggregates.	Sand.	0.29	0.31
		0.34	
		0.31	
	Glass Waste.	0.11	0.1
		0.12	
		0.09	

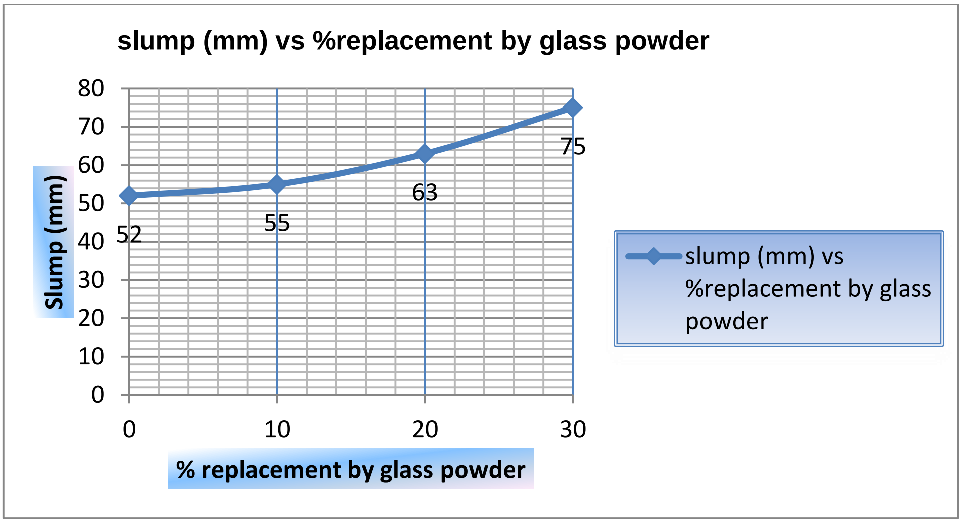
Workability Test Results

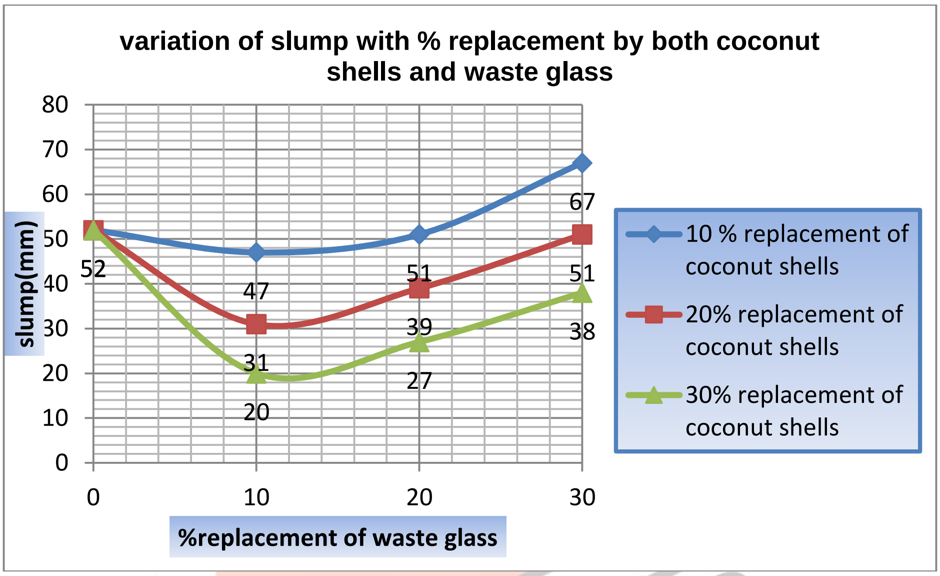
a). The slump values obtained in the slump cone test for various concrete mixes are tabulated below.

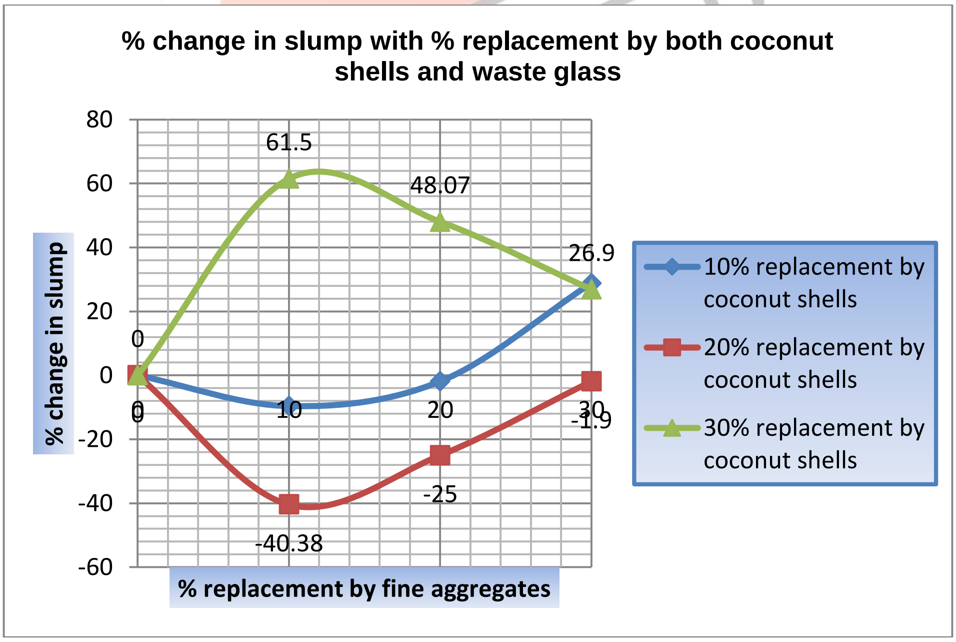
Table no. 6 : **Slump results**

Sample	Slump (mm)	% Change in slump
PCC	52	_
C_{10}	40	-23
C_{20}	25	-51
C_{30}	16	-69.23
F_{10}	55	5.76
F_{20}	63	21.15
F_{30}	75	44.23
$C_{10}F_{10}$	47	-9.61
$C_{10}F_{20}$	51	-1.9
$C_{10}F_{30}$	67	28.84
$C_{20}F_{10}$	31	-40.38
$C_{20}F_{20}$	39	-25
$C_{20}F_{30}$	51	-1.9
$C_{30}F_{10}$	20	61.5
$C_{30}F_{20}$	27	48.07
$C_{30}F_{30}$	38	26.9









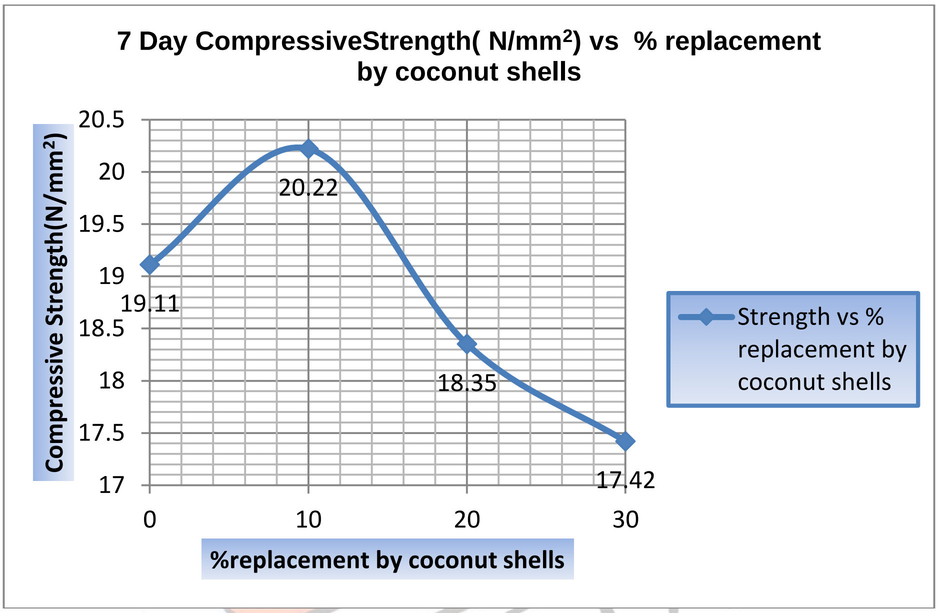
Compression Test Results

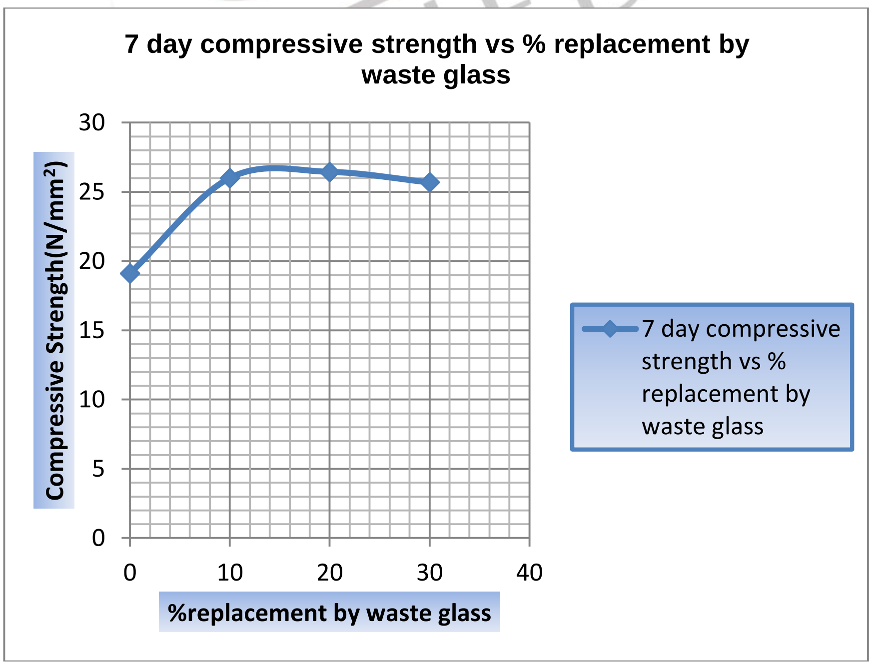
Cubes were placed in Compressive Testing Machine (C.T.M) and load was applied. The readings on dial gauge were recorded and compressive strength was calculated.

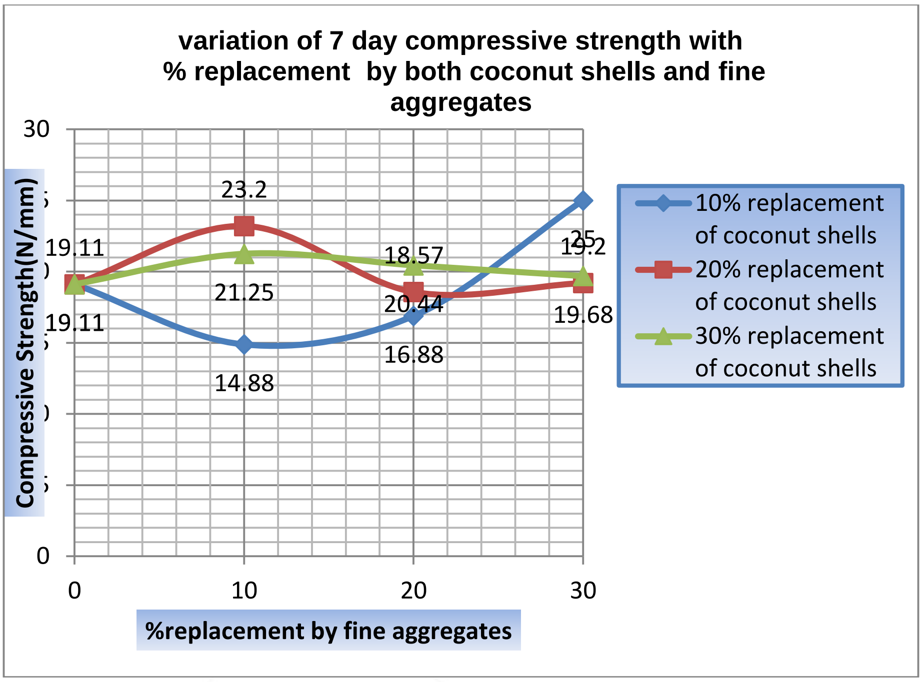
a). 7 Day Compressive strengths are tabulated below:

Table no. 7 : **7 day compression test results**

Sample	Strength (N/mm²)
PCC	19.11
C_{10}	20.22
C_{20}	18.35
C_{30}	17.42
F_{10}	26
F_{20}	26.44
F_{30}	25.68
$C_{10}F_{10}$	14.88
$C_{10}F_{20}$	16.88
$C_{10}F_{30}$	25
$C_{20}F_{10}$	23.2
$C_{20}F_{20}$	18.57
$C_{20}F_{30}$	19.2
$C_{30}F_{10}$	21.25
$C_{30}F_{20}$	20.44
$C_{30}F_{30}$	19.68



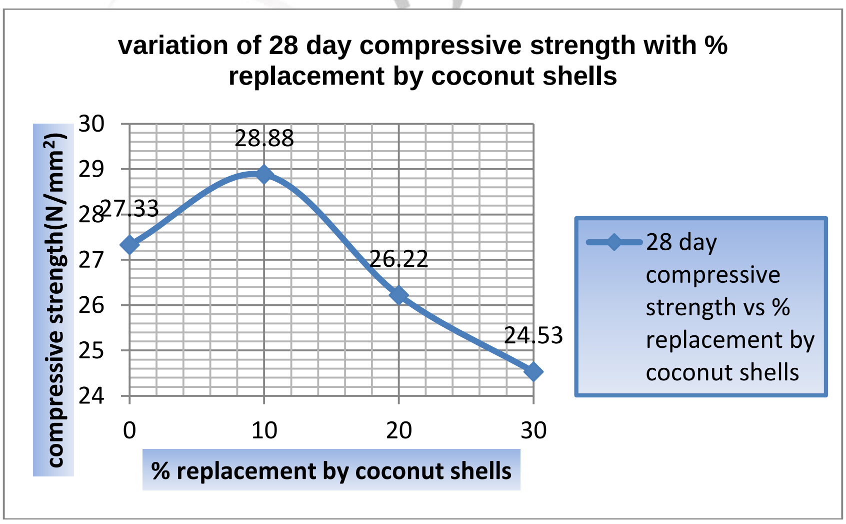


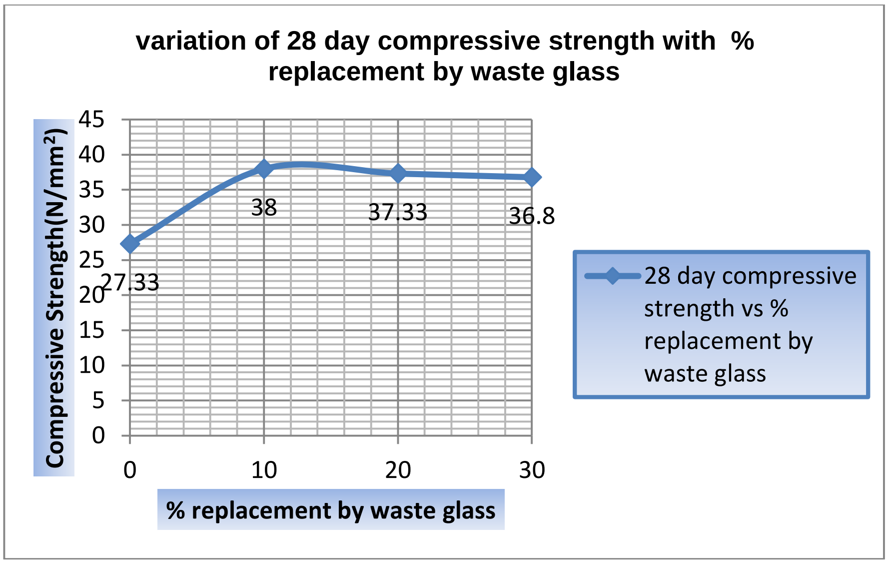


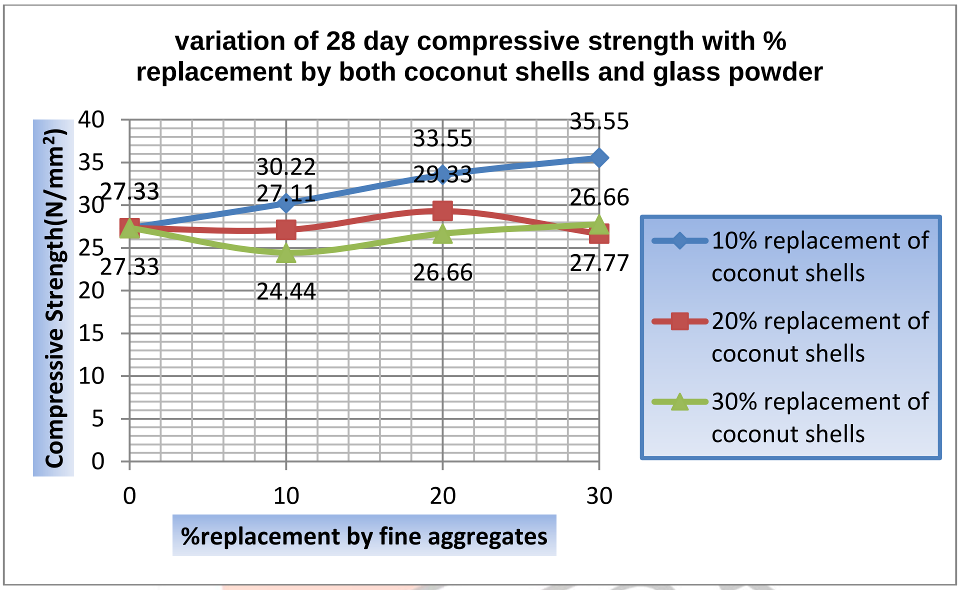
b). 28 Day Compressive strengths are tabulated below.

Table no.8 : **28 day compression test results**

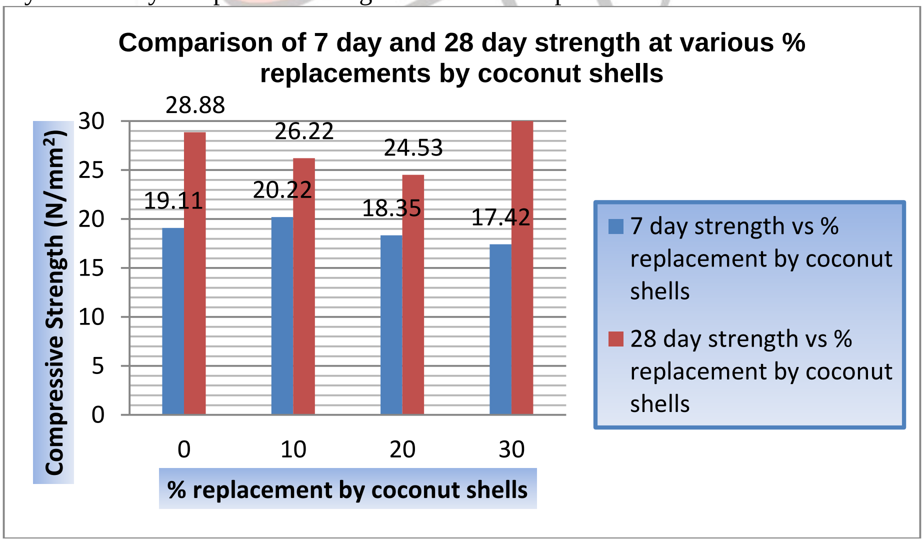
sample	Strength(N/mm^2)
PCC	27.33
C_{10}	28.88
C_{20}	26.22
C_{30}	24.53
F_{10}	38
F_{20}	37.33
F_{30}	36.8
$C_{10}F_{10}$	30.22
$C_{10}F_{20}$	33.55
$C_{10}F_{30}$	35.55
$C_{20}F_{10}$	27.11
$C_{20}F_{20}$	29.33
$C_{20}F_{30}$	26.66
$C_{30}F_{10}$	24.44
$C_{30}F_{20}$	26.66
$C_{30}F_{30}$	27.77

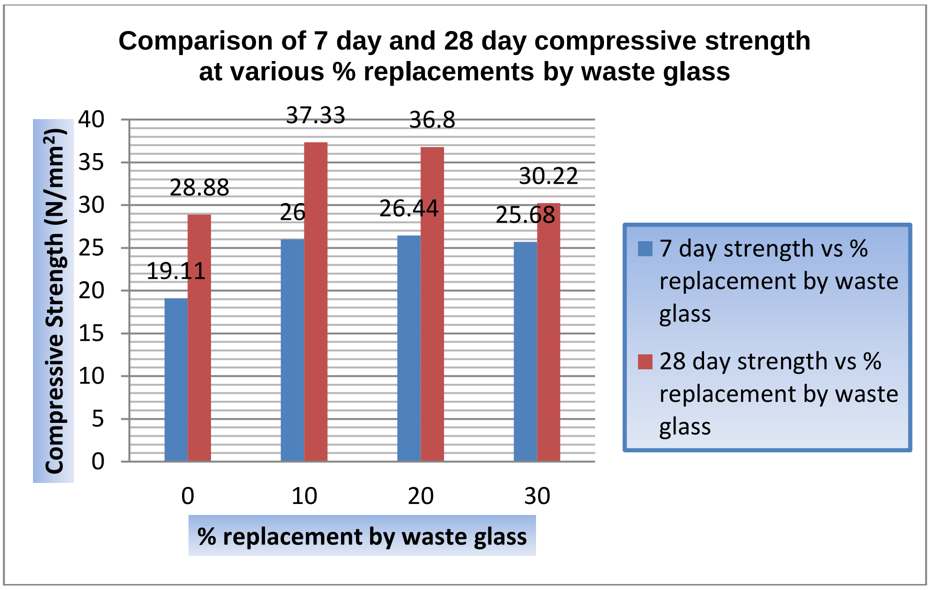


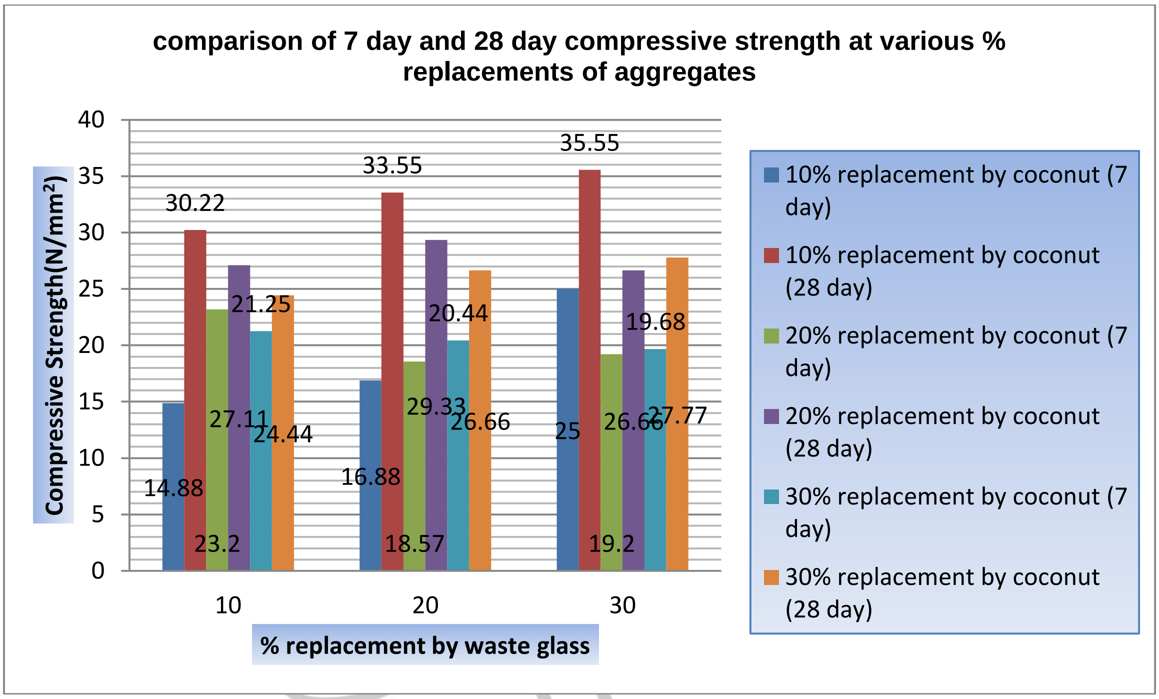




c). Comparison of 7 day and 28 day compressive strengths for various replaced mixes.







Flexure Test Results

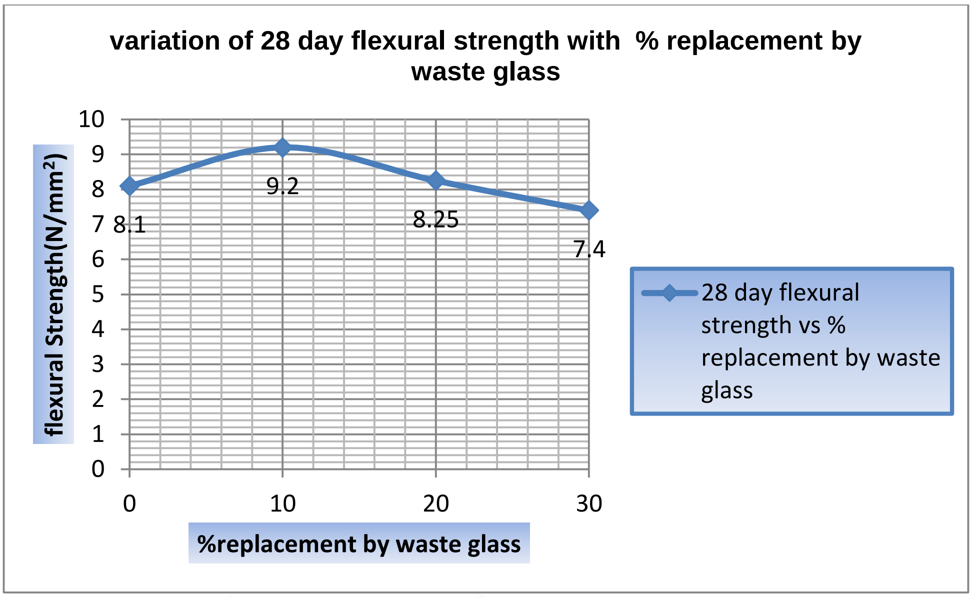
Prisms were tested in Universal Testing Machine (U.T.M) for determining the 28 day flexural strength.

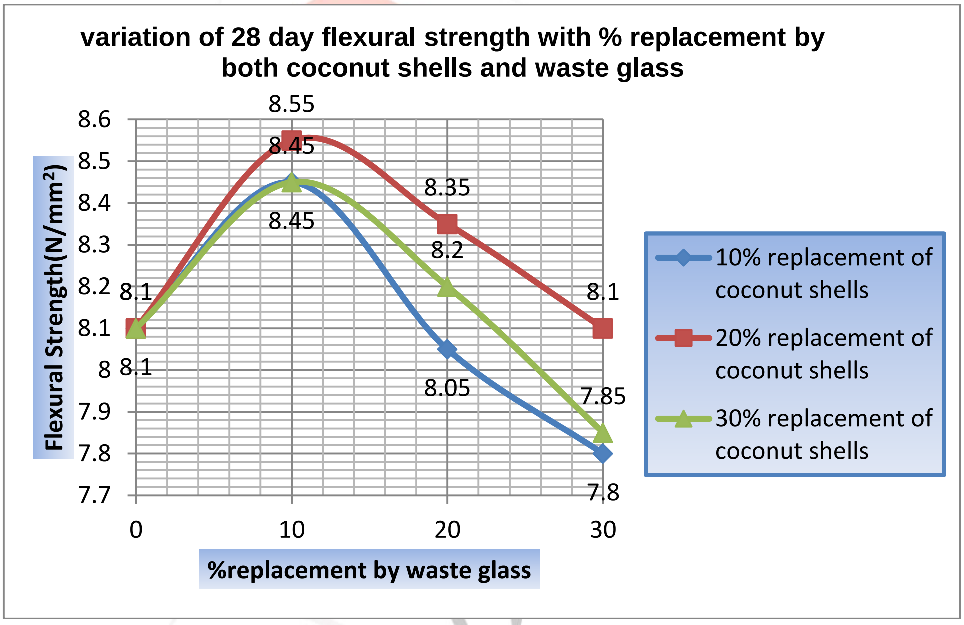
a). 28 day flexural strengths of different concrete mixes:

Table no. 9 : **28 day flexural strength**

Sample	Strength (N/mm^2)
PCC	8.1
C_{10}	8.4
C_{20}	8.2
C_{30}	7.85
F_{10}	9.2
F_{20}	8.25
F_{30}	7.4
$C_{10}F_{10}$	8.45
$C_{10}F_{20}$	8.05
$C_{10}F_{30}$	7.8
$C_{20}F_{10}$	8.55
$C_{20}F_{20}$	8.35
$C_{20}F_{30}$	8.1
$C_{30}F_{10}$	8.45

$C_{30}F_{20}$	8.2
$C_{30}F_{30}$	7.85





Result Interpretations

A) Fresh concrete.

Visual observations during mixing and compaction of all the concrete mixes suggested that the concrete mixes were homogeneous; there was no segregation and bleeding, the mixes were compactable. The fresh state performance of the Coconut Shell concretes was comparable with control concrete. The coconut shell replaced concrete mixes showed low slump values. The slump values for the coconut shell replaced concrete mixes were in between 16 - 40 mm from 10% replacement to 30% replacement. The slump value decreased with increase in coconut shell percentage. There was 69.23% reduction in slump for 30% replacement by coconut shells. However there was increase in slump with increasing percentage of waste glass. Slump value for waste glass concrete was between 55-75 mm . There was 44.23% increase in slump for 30% replacement by waste glass. This observation suggests that addition of coconut shells decreases workability and addition of waste glass as replacement of sand increases workability. The decreased workability of coconut shell concretes is due the higher porosity of coconut shells due to which there is increase in water absorption by coconut shells and as a result less water is available for the concrete. Decrease of workability may also be due to the shape of coconut shells , as flat shaped coconut shell particles could have restricted overall movement of the aggregate particles and thus reduced workability.

The increase in workability of waste glass concrete is due to fact that glasses don't absorb water and as a result more water is available for concrete.

When both coconut shells and waste glasses are added to the concrete there is either decrease or increase in slump value depending upon the percentage of coconut shells and waste glasses added to the concrete. For equal percentage replacement of coarse and fine aggregates by coconut shells and glass waste respectively there was an over all decrease in slump value for the concrete. E.g For $C_{30}F_{30}$ there is an overall 26.9 % decrease in slump value.

B) Hardened Concrete.

a). Compressive Strength.

There is increase in both 7 day and 28 day compressive strength of concrete upto 10% replacement of coarse aggregates by coconut shells but after increasing further the percentage of coconut shells there is gradual decrease in both 7 day and 28 day compressive strengths. 7 day strengths for C_{10} and C_{30} were found to be 20.22 MPa and 17.42 MPa respectively and 28 day strengths for C_{10} and C_{30} were found to be 28.88 MPa and 24.53 MPa respectively. As the percentage 0f coconut shell increases, the surface area increases, thus requiring more cement for proper bonding. Since cement content is constant, there is no extra bonding and hence strength reduces. Also with the increase in percentage replacement of coarse aggregates by coconut shell there is decrease in workability and as a result there isn't proper compaction of the mix due to which density is reduced and as a result over all compressive strength decreases.

In case of replacement to fine aggregates, it has been found that there is gradual increase in 7 day compressive strength upto 20 % replacement of fine aggregates by waste glass and by further increase in waste glass upto 30 % there is slight decrease in compressive strength but over all strength is more than PCC even for 30% replacement of fine aggregates by waste glass. For F_{10} ,F_{20} and F_{30} the 7 day compressive strength is 26 MPa ,26.44 MPa and 25.68 Mpa respectively. In case of 28 day compressive strength, firstly there is increase in compressive strength upto 10% replacement of fine aggregates by waste glass and after that further increase results in slight decrease in compressive strength upto 30% replacement but over all strength remains always higher than PCC. For F_{10}, F_{20} and F_{30} the 28 day compressive strengths were found to be 38 MPa ,37.33 MPa and 36.8 MPa respectively.

The increase in compressive strength due to the replacement of fine aggregates by waste glass is due to the reason that water absorption by waste glass is less as compared to sand and as a result more water is availabe for hydration reaction. The

slight decrease in compressive strength at higher percentage replacement of fine aggregates by waste glass is due to the alkali silica reaction which occurs due to the reaction between alkalis in Portland cement and silica in glass and forms silica gel. This gel is prone to swelling. It absorbs water and volume of the gel increases , as a result swelling of ASR gel generates hydrostatic pressure and cracks are developed which decrease the strength of concrete.

In case of combined replacement of coarse and fine aggregates, it has been found that 7 day compressive strength is maximum for $C_{10}F_{30}$ concrete mix and minimum for $C_{10}F_{10}$. A similar trend was found in case of 28 day compressive strength which is also maximum at 10 % replacement of coarse aggregates by coconut shells and 30% replacement of fine aggregates by waste glass. Hence for improving the over all compressive strength, the $C_{10}F_{30}$ mix is found to be appreciable whose strength is found to be 30.07 % more than that of PCC.

b). Flexural Strength.

On partially replacing the coarse aggregates by coconut shells, the 28 day flexural strength increases upto 10% replacement and decreases gradually on further replacements upto 30%. The 28 day flexural strength increases from 8.1 MPa for plain M20 concrete to 8.4 MPa for 10% coarse aggregate replaced concrete.

In case of percentage replacement of fine aggregates by glass waste, the 28 day flexural strength also increases upto 10% replacement and shows gradual decrease on further replacements. The flexural strength at 10% replacement is found to be more than plain M20 concrete (13.5 % increase) and for 20% replacement the flexural strength is almost same as that plain M20 concrete. However at 30% replacement of fine aggregates the flexural strength is less than plain M20. Hence for increasing 28 day flexural strength by partial replacement of fine aggregates by glass waste, 10% replacement is appreciable.

In case of combined replacement of coarse and fine aggregates, the 28 day flexural strength increases upto 10% replacement of fine aggregates for all the replacements

of coarse aggregates from 10% to 30%. The maximum flexural strength has been found at 20% replacement of coarse aggregates by coconut shells and 10% replacement of fine aggregates by waste glass. There is 5.26% increase in flexural strength of concrete when there is 20% replacement of coarse aggregates and 10% replacement of fine aggregates. The overall 28 flexural strength is found to be appreciable upto 10% replacement of fine aggregates in combination with all the replacements of coarse aggregates from 10% to 30%.

7. CONCLUSIONS AND RECOMMENDATIONS.

In the contemporary civil engineering construction, Economy of any construction project depends upon its construction, advancement and sustainability. Using alternative materials in place of natural aggregates in concrete production makes concrete as sustainable and environmental friendly construction material. Use of solid waste can achieve economy in construction. This study concluded that the utilisation of coconut shells and glass solid waste as aggregates in concrete not only helps in getting them utilized in concrete but also has numerous indirect benefits such as reduction in land fill cost and protecting environment from possible pollution effect. With increasing concern over the excessive exploitation of natural aggregates, this environmental waste compromising of coconut shells and waste glass is a viable new source of structural aggregate material.

The study concluded that up to 10% replacement of coarse aggregates by coconut shells and up to (20-30) percent replacement of fine aggregates by waste glass, compressive strength increases. Also there is an increase in the flexural strength of concrete up to 10% replacement of fine aggregates in combination with replacement of coarse aggregates from 10% to 30%.Hence, Coconut Shell and waste Glass can be effectively used as coarse and fine aggregate replacement up to 20% to improve the strength of concrete. Among various mixes compressive strength is maximum for the mix in which fine aggregates are replaced by 10% waste glasses. Its strength has increased by about 39% compared to the conventional M20 concrete.Flexural strength is also maximum for the mix in which fine aggregates are replaced by 10% waste glasses. Its flexural strength has increased by 13.5 percent compared to conventional M20 concrete. When both the coarse aggregates and fine aggregates are replaced by coconut shells and waste glasses respectively, compressive strength is maximum for the mix in which there is 10% replacement by coconut shells and 30% replacement by waste glass. Its strength has increased by about 30%. Also flexural strength is maximum for the mix in which there is 20% replacement by coconut shells and 10% replacement by waste glass. Its flexural strength has increased by 5.5%.

Partially replaced concrete is relatively light weight than conventional concrete which is economical, eco friendly and used in light weight structure where we have to minimize dead loads especially in earthquake prone zones. Coconut shells possesses sound absorbing property up to certain extent hence study is helpful for sound absorbing structures. Also coconut shell exhibits more resistance against crushing, impact and abrasion, compared to crushed granite aggregate. Coconut shell can be grouped under lightweight aggregate. There is no need to treat the coconut shell before use as an aggregate except for water absorption. Coconut shell is compatible with the cement. The 28-day air-dry densities of coconut shell aggregate concrete are less than 2000 kg/m^3 and these are within the range of structural lightweight concrete.

Due to the replacement of course aggregates by coconut shells workability decreases but due to the replacement of fine aggregates by waste glasses workability increases. So the study concluded that when both the course aggregates and fine aggregates are replaced by coconut shells and waste glasses respectively there is not much effect on workability compared to conventional concrete as the effects are counter balanced in these mixes. When the percentage replacement by coconut shells is higher, some plasticizers or super plasticizers can be used to have good workability.

Future work and Recommendations

1. Studies can be made to investigate the various properties of the partially replaced concrete with coconut shells and waste glass by varying the aggregate sizes up to acceptable limits. Study can also be made to check the split tensile strength of such partially replaced concrete.
2. Coconut shells as partial replacement of coarse aggregates can be effectively executed in areas where coconut shells is present in abundant quantity.
3. Provisions should be made to convert coconut and waste glasses into suitable aggregate form on a large scale in order to make the concrete industry more sustainable.
4. It is appreciable to replace fine aggregates by 10% to 30 % glass waste and coarse aggregates by 10% coconut shells in the areas of their availability in order to make concrete sustainable in terms of economy and more eco friendly.

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